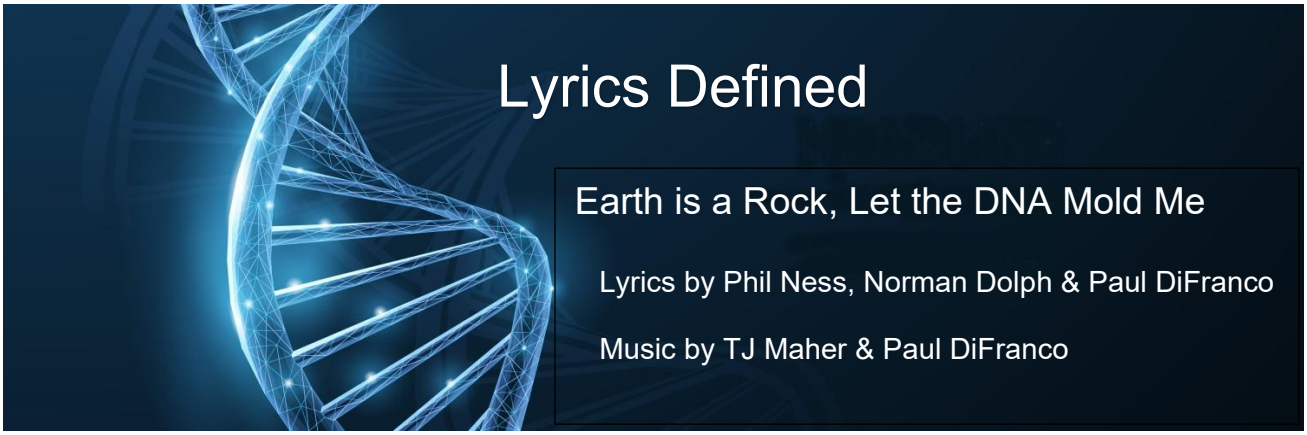

1. Gregor Johann Mendel, the father of modern genetics, established many of the rules of heredity in the 19th century, now known as the laws of Mendelian inheritance.

2. Apian describes anything having to do with bees that are essential for plant pollination. Stingers is a reference to the 'pointed' defensive end of bees.

3. Rachel Carson was a biologist and conservationist whose book *Silent Spring* published in 1962, and whose other writings are credited with advancing the global environmental movement.

4. Barbara McClintock was awarded the 1983 Nobel Prize in Physiology or Medicine "for her discovery of mobile genetic elements" or "jumping genes." She was the first woman to receive an unshared Nobel Prize.

5. Hedy Lamarr was a world-renowned actor, and co-inventor with composer and pianist George Antheil of frequency hopping, the foundation of today's cell phone and other telecommunication technologies.

6. Biotechnology refers to the use of technology based on biology to harness cellular and biomolecular processes to develop technologies and products that help improve our lives and the health of the planet. Fermentation is a biological

process that was first used 8,000 BCE to make bread, beer, wine, cheese, and other dairy products. Modern biotechnology provides breakthrough products and technologies to combat debilitating and rare diseases, reduce our environmental footprint, feed increasing populations, and use cleaner energy.

7. Locomotion in biology describes how various organisms move. Many bacteria and protozoa are capable of locomotion through slithering or wiggling. The mode of locomotion used by an animal depends on the size of the animal and medium in which it moves— air, land or water.

8. Deeper purple and liquefaction are references to the black plague (1347-1351) one of the most devastating pandemics in human history resulting in the deaths of an estimated 75 to 200 million people worldwide. The black plague still exists today.

9. Charles Darwin, Alfred Russel Wallace and Herbert Spencer were 19th century authors of the “theory of natural selection.”

10. The becquerel (Bq) is the SI derived unit of radioactivity. One Bq is defined as the activity of a quantity of radioactive material in which one nucleus decays per second. The Bq is named after Henri Becquerel, who shared a Nobel Prize in Physics with Pierre and Marie Curie in 1903 for their work in discovering radioactivity.

11. Sir Bernard Katz shared the 1970 Nobel Prize in physiology or medicine with Ulf von Euler and Julius Axelrod "for their discoveries concerning the humoral transmitters in the nerve terminals and the mechanism for their storage, release and inactivation."

12. A hormone is any member of a class of signaling molecules produced by glands in multicellular organisms that are transported by the circulatory system to target

distant organs to regulate physiology and behavior. The glands that secrete hormones comprise the endocrine signaling system.

13. Adrenotropin refers to a hormone of the anterior pituitary that stimulates the production of steroids in the cortex of the adrenal glands.

14. The pituitary gland is the major endocrine gland important in controlling growth, development and the functioning of the other endocrine glands.

15. The Earth is a terrestrial rocky planet. Within our Solar System, the terrestrial planets are the inner planets closest to the Sun, and include Mercury, Venus, Earth and Mars.

16. DNA, the foundation of all life on Earth, is composed of four nucleotides that are made up of three parts: a phosphate group, a 5-carbon sugar, and a nitrogenous base. The four nitrogenous bases in DNA are: Adenine (A), Thymine (T), Guanine (G), and Cytosine (C); (A always pairs with T, and G always pairs with C). The total length of the human genome is over three billion base pairs.

17. Nanotechnology (nano) is science, engineering and technology conducted at the nanoscale. A nanometer is one billionth of a meter or about one ten-thousandth the diameter of a human hair.

18. At the end of many careers lies a retired emboldened oldie.

19. The four nitrogenous bases in DNA are: Adenine (A), Thymine (T), Guanine (G), and Cytosine (C); (A always pairs with T, and G always pairs with C). The total length of the human genome is over three billion base pairs.

20. A bit has a single *binary* value, either 0 or 1. “Bits are click’in’” refers to the integration of the computer binary bits 1’s and 0’s with the DNA’s A, T, C & G nucleotides.

21. Docking in biology refers to a receptor or lock that binds to a “receiving” molecule.

22. Atossa, daughter of Cyrus the Great, was the first recorded case of breast cancer and mastitis (550 BC - 475 BC).

23. Florence Sabin was a pioneering medical scientist and in 1871 became the first woman appointed to the faculty of the Johns Hopkins University School of Medicine. In 1924, Dr. Sabin was the first woman elected president of the American Association of Anatomists, and a year later she became the first woman elected to membership of the National Academy of Sciences. In 1945, coming out of retirement, she became an activist in Colorado for healthcare overcoming numerous political obstacles. The “Sabin Health Laws” modernized public health in Colorado.

24. John Hill published a study in 1761 that linked excessive use of snuff with cancer, the first such correlation.

25. John Enders, known as "The Father of Modern Vaccines,” was awarded the Nobel Prize in Physiology or Medicine in 1954 with Thomas H. Weller and Frederick C. Robbins "for their discovery of the ability of poliomyelitis viruses to grow in cultures of various types of tissue."

26. Waring and other blenders brands are commonly used in laboratories for mixing and blending.

27. Linus Pauling was a biochemist and peace activist who was awarded the Nobel Prize in Chemistry in 1954 "for his research into the nature of the chemical bond and its application to the elucidation of the structure of complex substances." In 1962, Pauling was awarded the Nobel Peace Prize, one of only six to receive two Nobel prizes.

28. Jonas Salk was a medical researcher and virologist who discovered and developed one of the first successful polio vaccines launched in 1955. In 1960, he founded the Salk Institute for Biological Studies in La Jolla.

29. Rita Levi-Montalcini was awarded the 1986 Nobel Prize in Physiology or Medicine jointly with Stanley Cohen “for the discovery of nerve growth factor.” In 2001, she was appointed to the Italian Senate as a “Senator for Life”, an honor given due to her significant scientific contributions.

30. Robert Koch was the founder of modern bacteriology who identified the specific causative agents of tuberculosis, cholera and anthrax. Koch was awarded the 1905 Nobel Prize in Physiology or Medicine "for his investigations and discoveries in relation to tuberculosis."

31. Dr. Joe and Chris are retired biotechnology scientists from the Seattle area, and were patient educators of the author.

32. Robert Day was appointed director of the Seattle-based Fred Hutchinson Cancer Research Center in 1981, succeeding the founding director Dr. William Hutchinson. After retiring from the Fred Hutch in 1997, Dr. Day stayed active in life science startups, boards and advisory work. In 1989, Day served as a member of the Governor’s Biotechnology Advisory Committee in Washington State managed by the song’s author.

33. Richard Smalley, along with Robert Curl and Harold Kroto**,** was awarded the 1996 Nobel Prize in Chemistry “for their discovery of fullerenes,“ a new form of carbon, buckminsterfullerene, also known as Buckyballs.

34. Richard Buckminster Fuller was an architect, theorist, author, designer, inventor and futurist. Fuller popularized the widely known geodesic dome. Carbon molecules are named fullerenes by scientists for their structural and mathematical resemblance to geodesic spheres.

35. Scientists use agar as a medium to culture or grow microorganisms.

36. Gender basis, a word play with bias, is an ongoing issue in the workplace and well as with clinical trials. Historically, clinical trials have not adequately enrolled women or analyzed sex-specific or race differences in the data. Similar issues involve orphan drug and pediatric related trials.

37. Victor McKusick, Professor of Medicine at the Johns Hopkins Hospital, known as the "father of medical genetics" was a proponent of the human genome mapping project. In 1990, the U.S. Human Genome Project was launched and coordinated by the U.S. Department of Energy and the National Institutes of Health. The $3 billion project, originally planned to last 15 years, was completed in 2003 due to rapid advancements in technology.

38. Howard T. Ricketts discovered that the vector for Rocky Mountain spotted fever is a tick. In 1910, Ricketts became interested in a strain of murine carried in Mexico City, and the apparent similarity of the disease to spotted fever. Days after isolating the organism that he believed caused typhus, he died of the disease.

39. The 1962 Nobel Prize in Physiology or Medicine was awarded jointly to Francis Crick, James Watson and Maurice Wilkins "for their discoveries concerning the molecular structure of nucleic acids and its significance for information transfer in

living material." Rosalind Franklin, whose work contributed to the discovery, died before this date and the rules do not allow a Nobel Prize award posthumously.

40. Arthur Kornberg was a biochemist awarded the 1959 Nobel Prize in Physiology or Medicine along with Severo Ochoa of New York University, “for the discovery of the mechanisms in the biological synthesis of deoxyribonucleic acid (DNA)."

41. The 2018 Nobel Prize in Chemistry was awarded jointly to Frances H. Arnold "for the directed evolution of enzymes," and to George P. Smith and Sir Gregory P. Winter "for the phage display of peptides and antibodies."

42. Felix Franks was a leading authority on the water molecule who published “*A Matrix of Life”* in 2000 and developed new freeze-drying techniques for vaccines.

43. Twisted double helix describes the structure of a DNA molecule. A DNA moleculeconsists of two strands that wind around each other like a twisted ladder. Each strand has a backbone made of alternating groups of sugar (deoxyribose) and phosphate groups.

44. The 1984 Nobel Laureate in Medicine was awarded jointly to Niels Jerne, Georges Köhler and César Milstein “for theories concerning the specificity in development and control of the immune system and the discovery of the principle for production of monoclonal antibodies.”

45. The RIDER Institute, founded by Todd H. Rider, is dedicated to revolutionary innovation, development, education and research.

46. The 1980 Nobel Laureate in Chemistry was awarded jointly to Walter Gilbert and Frederick Sanger "for their contributions concerning the determination of base sequences in nucleic acids,” and to Paul Berg “for his fundamental studies of the biochemistry of nucleic acids, with particular regard to recombinant-DNA.”

47. K. Barry Sharpless from The Scripps Research Institute in La Jolla, CA, was awarded the 2001 Nobel Prize for Chemistry “for his work on chirally catalysed oxidation reactions.”

48. The Sackler brothers, Mortimer and Raymond acquired Purdue Pharma in 1952, and in 1962 they introduced their opioid drug, OxyContin. Purdue Pharma reported cumulative OxyContin revenues of $35 billion in 2017. In Sept. 2019, Purdue Pharma filed for Chapter 11 bankruptcy.

49. A vaccination is a substance used to stimulate immunity to a particular infectious disease or pathogen, typically prepared from an inactivated or weakened form of the causative agent or from its constituents or products.

50. Mutation describes a change that occurs in our DNA sequence, either due to mistakes when DNA is copied or as the result of environmental factors such as UV light, cigarette smoke, radiation exposure, etc. The DNA sequences of the infectious diseases defended against also mutate in response to the vaccine – resulting in a biological arms race.

51. Ribonucleic acid (RNA) is a molecule like DNA composed of four bases Adenine (A), Guanine (G), Cytosine (C), and Uracil (U). Several types of RNA exist in the cell: messenger RNA (mRNA), ribosomal RNA (rRNA) and transfer RNA (tRNA).

52. Transformation is the genetic alteration of a cell resulting from the uptake and incorporation of exogenous genetic material from its surroundings through the cell membrane(s).

53. The 1993 Nobel Prize in Chemistry was jointly awarded to Kary B. Mullis "for his invention of the polymerase chain reaction (PCR) method" and Michael Smith "for his fundamental contributions to the establishment of oligonucleotide-based, site-directed mutagenesis and its development for protein studies." PCR is commonly used in molecular biology to make many copies of a specific DNA segment.

54. “Exploding stars,” also known as supernovae, is a reference to planet building.

55. In 1976, Genentech was founded by venture capitalist Robert Swanson, geneticist Stanley Cohen from Stanford University, and biochemist Dr. Herbert Boyer from the University of California, San Francisco. In the early 1970s, Boyer pioneered recombinant DNA technology. In 2009, Genentech became a Roche subsidiary.

56. An entrepreneur is a person who organizes and operates a business or businesses, taking on greater than normal financial risks.

57. Johnson & Johnson (JNJ), founded in 1886, is one of the oldest and largest healthcare companies in the United States.

58. The Mayo brothers: William and Charles, were sons of Dr. William Worrall Mayo the founder of the Mayo Clinic established in 1868 in Rochester, Minnesota. Today, the Mayo Clinic is one of the leading medical centers worldwide.

59. **A**pplied **M**olecular **Gen**etics (AMGen) was the original name of Amgen, today one of the world’s largest biotechnology companies. In 1980, George Rathmann was appointed CEO of the new company.

60. Sir Alec Jeffreys and technician Vicky Wilson discovered minisatellites in 1984, leading to the development of genetic fingerprinting or DNA forensics.

61. The chromosome is a threadlike structure of nucleic acids and protein found in the nucleus of living cells, carrying genetic information in the form of genes. In humans, each cell normally contains 23 pairs of chromosomes.

62. A genome is an organism’s complete set of DNA, including all genes. Each genome contains all the information needed to build and maintain that organism.

In humans, a copy of the entire genome—more than 3 billion DNA base pairs—is contained in all cells that have a nucleus.

63. John King worked with two Seattle biotechnology companies and was co-chair with George Rathmann of the Washington State Governor's Biotechnology Advisory committee, staffed by the song's author. King, co-founded, with his wife Pam, The Common Flat Project, a conservation organization dedicated to creating awareness of the importance of Earth's biodiversity, especially on Cape Cod.

64. Walter W. King showed the transmission of Rocky Mountain spotted fever by using infected ticks on guinea pigs.

65. Mary-Claire King is an internationally known human geneticist. She is the American Cancer Society Professor of Genome Sciences and of Medical Genetics in the Department of Medicine at the University of Washington. Some of Dr. King's achievements include identifying the BRCA1 gene responsible for inherited susceptibility to breast cancer; demonstrating that the genomes of humans and chimpanzees are 99% genetically identical; and pioneering the application of genomic sequencing methods in forensics to identify victims of human rights abuse.

66. "Free Thinking" means forming opinions based on reason, independent of authority or tradition. The term "Free Thought" first came into use in the 17th century to indicate people who inquired into the basis of traditional religious beliefs. The pansy has long been a symbol of free thought.

67. Emmanuelle Charpentier has been Director at the Max Planck Institute for Infection Biology since 2015. Charpentier is best known for deciphering the molecular mechanisms of the bacterial CRISPR/Cas9 immune system and repurposing it into a tool for genome editing. In collaboration with Jennifer

Doudna's lab, Charpentier's lab showed that Cas9 can be used to make cuts in any DNA sequence desired.

The Nobel Prize in Chemistry 2020 was awarded to Emmanuelle Charpentier and Jennifer Doudna "for the development of a method for genome editing."

68. Jennifer Doudna is a biochemist at the University of California, Berkeley and is a leading figure in what is the "CRISPR revolution" for her fundamental work and leadership in developing CRISPR-mediated genome editing.

69. John Glenn was a U.S. Marine Corps aviator, astronaut, businessperson and politician. He was one of seven Mercury ("**Merc"**) program astronauts and the first American to orbit the Earth, circling it three times in 1962. Following his retirement from NASA, he served from 1974 to 1999 as a U. S. Senator from Ohio. In 1998, Glenn flew into space for a second time at age seventy-seven.

70. George W. Rathmann was a chemist, biologist, and pioneer in biotechnology. In 1980 he served as the first CEO of Amgen, and later ICOS. Rathmann received the first Biotechnology Heritage Awards from the Biotechnology Industry Organization and the Chemical Heritage Foundation in 1999 in recognition of his career as a scientist and entrepreneur.

71. CRISPR (**C**lustered **R**egularly **I**nterspaced **S**hort **P**alindromic **R**epeats) is a family of DNA sequences found within the genomes of prokaryotic organisms such as bacteria and archaea. This is the bacterial defense system that forms the basis for CRISPR-Cas9 genome editing technology. In the field of genome engineering, "CRISPR" and related systems (e.g. CRISPR-Cas9m) can be programmed to target specific stretches of genetic code and to edit DNA at precise locations. With these systems, researchers can permanently modify genes in living cells and organisms and, in the future, may make it possible to correct mutations at precise locations in the human genome to treat genetic causes of disease.

72. Mary-Claire King is an internationally known human geneticist. She is the American Cancer Society Professor of Genome Sciences and of Medical Genetics in the Department of Medicine at the University of Washington. Some of Dr. King's most noteworthy achievements include identifying the BRCA1 gene responsible for inherited susceptibility to breast cancer; demonstrating that the genomes of humans and chimpanzees are 99% genetically identical; and pioneering the application of genomic sequencing methods in forensics to identify victims of human rights abuse.

73. Leland H. Hartwell, former Director of the Fred Hutchinson Cancer Research Center, was awarded the 2001 Nobel Prize for Medicine “for discoveries of key regulators of the cell cycle.”

74. Linda B. Buck from the Fred Hutchinson Cancer Research Center, was awarded the 2004 Nobel Prize for Medicine “for discoveries of odorant receptors and the organization of the olfactory system.”

75. E. Donnall "Don" Thomas from the Fred Hutchinson Cancer Research Center, "the father of bone marrow transplantation," was awarded the 1990 Nobel Prize “for Medicine for discoveries concerning organ and cell transplantation in the treatment of human disease.”

76. *Electrophoresis* is a technique commonly used in labs to separate charged molecules like DNA, RNA and proteins according to their size.

77. California is the birthplace of modern biotechnology, and a leading life science center.

78. New York is a leading pharmaceutical center in the U.S.